European Stategy: il processo e le conclusioni

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Giornate sulla European Strategy for Particle Physics
Sezione INFN Roma1 20-21 Settembre 2020

The ESPP

The European Strategy for Particle Physics is the cornerstone of Europe's decision-making process for the long-term future of the field. Mandated by the CERN Council, it is formed through a broad consultation of the grass-roots particle physics community, it actively solicits the opinions of physicists from around the world, and it is developed in close coordination with similar processes in the US and Japan in order to ensure coordination between regions and optimal use of resources globally.

CERN Council Open Symposium on the Update of

European Strategy for Particle Physics

13-16 May 2019 - Granada, Spain

European Strategy Update

European Strategic Group

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Dr Abid Patwa (United States of America)

Organisations with Observer status
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Professor Boris Sharkov (JINR)

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Physics Briefing book

CERN-ESU-004
10 January 2020

Physics Briefing Book

Input for the European Strategy for Particle Physics Update 2020

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arXiv:1910.11775v2 [hep-ex] 10 Jan 2020

Physics Briefing book – la summa !

Contents

European Particle Physics Strategy *Update*

European Strategy Update

2017 | **2018** | **2019** | **2020**

Jan.2018
Call for proposals for venues for Open Symposium and Strategy Drafting Session
(deadline May 15, 2018)

Febr.2018
Call for scientific input

March.2018
Call for nominations of PPG & ESG members

June.2018
Council decision on venues and dates

Sept.2018
Council to launch the Strategy Update process & establish the PPG and ESG

organisation & input preparation by community

Dec.2018
Closing submission community input
(deadline Dec 18, 2018)

***2nd half of* May.2019**
Open Symposium
4 days

Sept.2019
Physics Briefing Book available

consultation & consensus building

Physics results appearing after May 2019 will be taken into account in the process

***2nd half of* Jan.2020**
Strategy Update Drafting Session
one week

March.2020
Strategy Update submitted to Council

May.2020
Council to approve Strategy Update

June 2020

Il percorso in Europa nel 2019-20

- 13-16 Mag 2019: Open Symposium (Granada)
- 13 Lug 2019: Sessione speciale ECFA/EPS (EPSHEP-2019, Ghent)
- Settembre 2019: consegna Briefing Book da PPG a ESG
- 20-24 Gen 2020: Strategy Drafting Session (Bad Honnef)
- Mar 2020: discussione della bozza di Strategy nel Council
- Mag-Giu 2020: approvazione formale in Council Open Session

Il percorso INFN

- apr 2018: Incontro preparatorio in Presidenza
- set 2018: INFN Town Meeting - Roma
- ott 2018: Presentazione a giornate PTA – Bologna; Presentazione a meeting CVI – Napoli; Presentazione orale a Direttori e Presidenti CSN
- Fine 2018: sottomesso documento con il punto di vista dell'INFN
- 2019: Updates periodici a Direttori e Presidenti CSN; Presentazione a giornate PTA – Bari ; Presentazione a meeting CVI – Genova etc.

Elementi di discussione

	2020-2040 *HL-LHC era*	2040-2060 *Z/W/H/top-factory era*	2060-2080 *energy frontier era*
our technology	SCRF ~ 30 MV/m B ~ 11 T	SCRF ~ 50 MV/m B ~ 14 T plasma demo muon demo	SCRF ~ 70 MV/m B > 16 T (HTS?) plasma collider muon collider
other technology	AI for new physics quasi-online analysis digital imaging new transistors	quantum computing self-learning simulation	...
societal threats	eco friendly gases careers at mega-research facilities	energy consumption long-term engagement global vs sustained collaboration	human vs machine

Gli scenari discussi

	2020-2040	2040-2060	2060-2080
		1st gen technology	2nd gen technology
CLIC-all	HL-LHC	**CLIC380-1500**	CLIC3000 / other tech
CLIC-FCC	HL-LHC	**CLIC380**	FCC-h/e/A (Adv HF magnets) / other tech
FCC-all	HL-LHC	**FCC-ee (90-365)**	FCC-h/e/A (Adv HF magnets) / other tech
LE-to-HE-FCC-h/e/A	HL-LHC	**LE-FCC-h/e/A (low-field magnets)**	FCC-h/e/A (Adv HF magnets) / other tech
LHeC-FCC-h/e/A	HL-LHC + **LHeC**	**LHeC**	FCC-h/e/A (Adv HF magnets) / other tech

I costi .....

- CLIC-all costa 17 GEuro (tunnel 3.3 GE)
- FCC-all costa 26 GEuro (tunnel 5.4 GE)
- CLIC-FCC costa 31 GE (tunnel 6.7 GE)
- LE-FCC + HE-FCC costa 32 GE (tunnel 5.4 GE) (probabilmente la fase LE ne costa 15)
- LHeC + FCC costa 28 GE (tunnel 5,4 GE)

Stima grossolana senza TDR ...

La posizione INFN

Scenario	Main pro-contra arguments	INFN involvement, community support
CLIC	Precision measurements limited to Higgs and top. Indirect sensitivity to new physics comparable to FCC-hh only at 3 TeV	Very limited
CLIC+FCC-hh	Precision measurements limited to Higgs and top. Cost higher than full FCC.	Involvement only for the FCC-hh part
FCC	Precision measurements at Z, W, H and top, relatively easy machine, followed by direct broad exploration of new territory	Strong INFN community for both FCC-ee and FCC-hh
LE-to-HE-FCC	Could be an interesting option should ILC (or other e^+e^- colliders) start construction	Involvement from the LHC and FCC-hh communities
LHeC+FCC-hh	Gain from LHeC on Higgs couplings after HL-LHC limited. Investigations on u,d couplings and proton structure.	Expect limited participation to LHeC program, expect involvement mostly on HL-LHC and FCC-hh preparation.

INFN Argomenti a supporto

- We think that the ESPP update should be based on significant jump in precision (e.g. in Higgs boson properties) and broad exploration (e.g. search of new physics at the energy frontier)
- We believe that, out of the five proposed scenarios, the FCC-all option is the best one in this respect.
- In the FCC-ee phase electroweak physics will be studied with unprecedented precision not only in the sector related to the newly discovered scalar boson, but also in the Z, W and top quark sectors.
- The FCC-hh phase would guarantee in the best way direct broad exploration of new territories.

Le diverse posizioni

- L'opzione FCC-all era supportata da molte delegazioni incluse quelle di UK , F, DK che non avevano forti indicazioni dalla comunità
- Qualche delegazione suggeriva anche esplicitamente l'opzione LE-to HE-FFChh nel caso di ILC
- CLIC era l'opzione preferita dalla Norvegia e tollerata da pochi altri (ES, O, forse NL) che però volevano comunque una macchina a elettroni come priorità
- La Germania .....

Il Risultato:
ESPP resa pubblica il 19 Giugno

Strategy statements

CERN-ESU-013
June 2020

Update of the European Strategy for Particle Physics

by the European Strategy Group

Preamble

Nature hides the secrets of the fundamental physical laws in the tiniest nooks of space and time. By developing technologies to probe ever-higher energy and thus smaller distance scales, particle physics has made discoveries that have transformed the scientific understanding of the world. Nevertheless, many of the mysteries about the universe, such as the nature of dark matter, and the preponderance of matter over antimatter, are still to be explored.

This 2020 update of the European Strategy for Particle Physics proposes a vision for both the near-term and the long-term future. It aims to significantly extend knowledge beyond the current limits, to drive innovative technological development, and to maintain Europe's leading role in particle physics, within the global context. The 2013 update came shortly after the monumental discovery of the Higgs boson, which was a turning point for research in particle physics. The Large Hadron Collider (LHC) has established the crucial role of the Higgs boson in the acquisition of mass by the fundamental particles, but the observed pattern of masses remains an enigma. The Higgs boson is a unique particle that raises profound questions about the fundamental laws of nature. It also provides a powerful experimental tool to study these questions.

In the coming decade, the LHC, including its high-luminosity upgrade, will remain the world's primary tool for exploring the high-energy frontier. Given the unique nature of the Higgs boson, there are compelling scientific arguments for a new electron-positron collider operating as a "Higgs factory". Such a collider would produce copious Higgs bosons in a very clean environment, would make dramatic progress in mapping the diverse interactions of the Higgs boson with other particles and would form an essential part of a research programme that includes exploration of the flavour puzzle and the neutrino sector.

The exploration of significantly higher energies than the LHC will make it possible to study the production of Higgs boson pairs and thus to explore the particle's interaction with itself, which is key to understanding the fabric of the universe. Further, through the exploration of a new realm of energies, discoveries will be made and the answers to existing mysteries, such as the nature of dark matter, may be found. The particle physics community is ready to take the next step towards even higher energies and smaller scales. The vision is to prepare a Higgs factory, followed by a future hadron collider with sensitivity to energy scales an order of magnitude higher than those of the LHC, while addressing the associated technical and environmental challenges.

This Strategy presents exciting and ambitious scientific goals that will drive technological and scientific exploration into new and uncharted territory for the benefit of the field and of society.

1. Major developments from the 2013 Strategy

a) Since the recommendation in the 2013 Strategy to proceed with the programme of upgrading the luminosity of the LHC, the HL-LHC project, was approved by the CERN Council in June 2016 and is proceeding according to plan. In parallel, the LHC has reached a centre-of-mass energy of 13 TeV, exceeded the design luminosity, and produced a wealth of remarkable physics results. Based on this performance, coupled with the innovative experimental techniques developed at the LHC experiments and their planned detector upgrades, a significantly enhanced physics potential is expected with the HL-LHC. The required high-field superconducting Nb,Sn magnets have been developed. *The successful completion of the high-luminosity upgrade of the machine and detectors should remain the focal point of European particle physics, together*

1

Deliberation document

CERN-ESU-014

5 March 2020

Deliberation Document
on the 2020 update of the European Strategy for Particle Physics

The European Strategy Group
(prepared by the Strategy Secretariat)

The first European Strategy for Particle Physics (hereinafter referred to as "the Strategy"), consisting of seventeen Strategy statements, was adopted by the CERN Council at its special session in Lisbon in July 2006. A first update of the Strategy was adopted by the CERN Council at its special session in Brussels in May 2013. This second update of the Strategy was formulated by the European Strategy Group (ESG) during its six-day meeting in Bad Honnef in January 2020. The ESG was assisted by the Physics Preparatory Group, which had provided scientific input based on the material presented at a four-day Open Symposium held in Granada in May 2019, and on documents submitted by the community worldwide. In addition, six working groups were set up within the ESG to address the following points, and their conclusions were discussed at the Bad Honnef meeting:

Working Group 1: Social and career aspects for the next generation;
Working Group 2: Issues related to Global Projects hosted by CERN or funded through CERN outside Europe;
Working Group 3: Relations with other groups and organisations;
Working Group 4: Knowledge and Technology Transfer;
Working Group 5: Public engagement, Education and Communication;
Working Group 6: Sustainability and Environmental impact.

This Deliberation Document provides background information underpinning the Strategy statements. Recommendations to the CERN Council made by the Working Groups for possible modifications to certain organisational matters are also given. The structure of the updated Strategy statements closely follows the structure of the 2006 Strategy and its 2013 update, consisting of a preamble concerning the scientific motivation, followed by 20 statements:

1. two statements on **Major developments from the 2013 Strategy**
2. three statements on **General considerations for the 2020 update**
3. two statements on **High-priority future initiatives**
4. four statements on **Other essential scientific activities for particle physics**
5. two statements on **Synergies with neighbouring fields**
6. three statements on **Organisational issues**
7. four statements on **Environmental and societal impact**

Each Strategy statement gives a short description of the topic followed by the recommendation in italic text. Within the numbered sections there is no intention to prioritise between the lettered statements. In this Deliberation Document the Strategy statements are presented in blue indented text, and each statement is followed by some explanatory text.

Major developments from the 2013 Strategy

a) HL_LHC

~~been developed~~. *The successful completion of the high-luminosity upgrade of the machine and detectors should remain the focal point of European particle physics, together with continued innovation in experimental techniques. The full physics potential of the LHC and the HL-LHC, including the study of flavour physics and the quark-gluon plasma, should be exploited.*

b) Neutrino physics program

~~accelerator-based projects outside Europe~~. *Europe, and CERN through the Neutrino Platform, should continue to support long baseline experiments in Japan and the United States. In particular, they should continue to collaborate with the United States and other international partners towards the successful implementation of the Long-Baseline Neutrino Facility (LBNF) and the Deep Underground Neutrino Experiment (DUNE).*

Messaggio

→Completare High Luminosity LHC

→Supportare gli esperimenti Long Baseline sui neutrini negli USA e in Giappone

General considerations for the 2020 update

A. Reinforce the European Leadership in the field

~~projects~~. *This Strategy update should be implemented to ensure Europe's continued scientific and technological leadership.*

B. Exploit and strenght the organizational model

~~with non-Member States and their substantial contribution~~. *The particle physics community must further strengthen the unique ecosystem of research centres in Europe. In particular, cooperative programmes between CERN and these research centres should be expanded and sustained with adequate resources in order to address the objectives set out in the Strategy update.*

C. The complementary physics program

~~neighbouring fields~~. *The implementation of the Strategy should proceed in strong collaboration with global partners and neighbouring fields.*

Messaggio politico

→L'Europa ha la leadership scientifica e tecnologica in questo campo e la vuole mantenere

→L'Europa ha il CERN e una organizzazione unica per realizzare il Progetto

→Lavoriamo in sinergia con gli altri campi di ricerca

High - priority future initiatives

- the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;

- Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.

High - priority future initiatives

- The timely realisation of the electron-positron International Linear Collider (ILC) in Japan would be compatible with this strategy and, in that case, the European particle physics community would wish to collaborate.

High - priority future initiatives

- The European particle physics community must intensify accelerator R&D and sustain it with adequate resources. A roadmap should prioritise the technology, taking into account synergies with international partners and other communities such as photon and neutron sources, fusion energy and industry. Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes.

Other essential scientific activities for particle physics

❑ Flavor physics

Experiments in such diverse areas that offer potential high-impact particle physics programmes at laboratories in Europe should be supported, as well as participation in such experiments in other regions of the world

❑ Theoretical physics

Europe should continue to vigorously support a broad programme of theoretical research covering the full spectrum of particle physics from abstract to phenomenological topics. The pursuit of new research directions should be encouraged and links with fields such as cosmology, astroparticle physics, and nuclear physics fostered. Both exploratory research and theoretical research with direct impact on experiments should be supported, including recognition for the activity of providing and developing computational tools.

Other essential scientific activities for particle physics

❑ Detector R&D

Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large. Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.

Other essential scientific activities for particle physics

❑ Computing

The community must vigorously pursue common, coordinated R&D efforts in collaboration with other fields of science and industry to develop software and computing infrastructures that exploit recent advances in information technology and data science. Further development of internal policies on open data and data preservation should be encouraged, and an adequate level of resources invested in their implementation.

Synergies with neighbouring fields

❑ Nuclear physics

In the global context, a new electron-ion collider, EIC, is foreseen in the United States to study the partonic structure of the proton and nuclei, in which there is interest among European researchers. Europe should maintain its capability to perform innovative experiments at the boundary between particle and nuclear physics, and CERN should continue to coordinate with NuPECC on topics of mutual interest.

❑ Astroparticle physics

Astroparticle physics, coordinated by APPEC in Europe, also addresses questions about the fundamental physics of particles and their interactions. The ground-breaking discovery of gravitational waves has occurred since the last Strategy update, and this has contributed to burgeoning multi-messenger observations of the universe. Synergies between particle and astroparticle physics should be strengthened through scientific exchanges and technological cooperation in areas of common interest and mutual benefit.

Deliberation Document contiene anche questi statements

- the R&D for an effective breakthrough in plasma acceleration schemes (with laser and/or driving beams), as a fundamental step toward future linear colliders, possibly through intermediate achievements: e.g. building plasma-based free-electron lasers (FEL). Developments for compact facilities with a wide variety of applications, in medicine, photonics, etc., compatible with university capacities and small and medium-sized laboratories are promising;

Deliberation Document contiene anche questi statements

- an international design study for a muon collider, as it represents a unique opportunity to achieve a multi- TeV energy domain beyond the reach of e+e– colliders, and potentially within a more compact circular tunnel than for a hadron collider. The biggest challenge remains to produce an intense beam of cooled muons, but novel ideas are being explored;
- a vigorous R&D on high-intensity, multi-turn energy-recovery linac (ERL) machines, promoting the realisation of a demonstrator with a view also to low-energy applications.

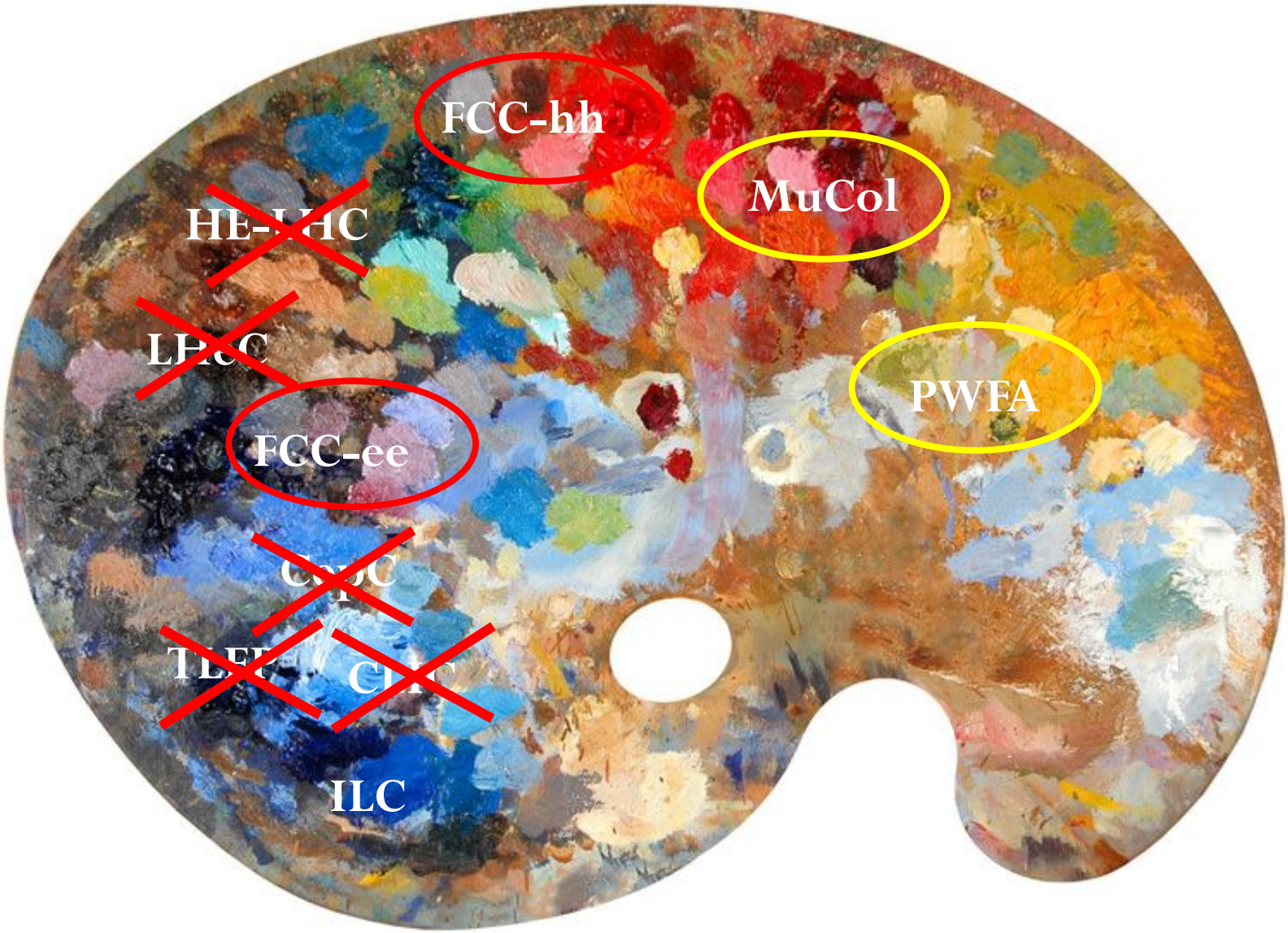
Alcune osservazioni

- FCC non era presente nella strategy precendente, ha un ruolo centrale in questo update →Si apre la stagione dei TRD per FCC-ee e FCC-hh e la fase preparatoria per il tunnel
- CLIC viene messo in secondo piano (vedi pagina 7 del deliberation document, non appare nel main document)
- La Beam Dump Facility non entra nel piano “such a project would be difficult to resource within the CERN budget, considering the other recommendations of this Strategy “
- Non si parla piu’ di HE-LHC (consistente con il risultato degli studi fatti per Granada)

Priorità nella ESPP

- Prima Priorità:
  - verifica fattibilità FCC
  - Magneti superconduttori
  - Tecniche accelerazione
- Altre attività:
  - Muon Collider
  - Diversity program
  - R&D detector, Computing
  - Fisica teorica

Un tavolozza ricca di colori - updated



L’IMPATTO DELLA ESPP SULLE NOSTRE ATTIVITA’ DI FISICA DELLE PARTICELLE AGLI ACCELERATORI IN EUROPA

L'impatto su INFN

- HL-LHC
- LBNF @ Fermilab
- R&D su rivelatori

→ TDR FCC

→ Programma Magneti superconduttori

→ Partecipazione Muon Collider

→ Programma Plasma acceleration: Eupraxia@LNF

L’impatto su INFN

- Einstein Telescope
- Attività presso Infrastrutture nazionali @LNGS, LNL, LNS
- Computing: Infrastruttura (Tecnopolo @ CNAF) + Quantum technologies

Grazie per l’attenzione !

Una possibile strategia

CLIC: (380+1.5+3)

- **Ready to be built!**
- **Remarkable Exploration Potential**
- Suffers from limited energy
- Possibly expensive

The FCC Project: (ee+hh+he)

- Challenging, definitely expensive
- **Does everything!**
- **The Dream Machine**

HE-LHC:

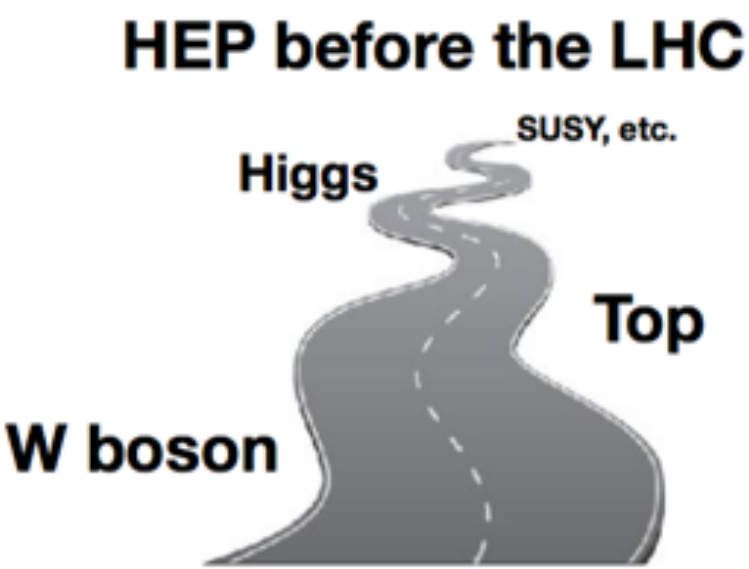
- LHC < HE-LHC < FCC
- **Better than nothing**

Muon collider: [or Plasma]

- 10 TeV >> LHC; 14 TeV ~ FCC-hh; 30 TeV = amazing
- **Not yet clear we can dream of it!**
- **I discourage focusing on Higgs pole** [ask me why]

Wulzer

Future Collider



Particle physics is not **validation** anymore, rather it is **exploration of unknown territories** *

Wulzer